

**5-alt REPORT FOR CROOKED FORK AND FLAT FORK
IN THE EMORY RIVER WATERSHED (06010208)**

AN ALTERNATIVE RESTORATION APPROACH UNDER THE LONG-TERM VISION FOR TMDLs

Tennessee Department of Environment and Conservation
Division of Water Resources



September 18, 2018

Background.

EPA's current [Vision](#) for the Clean Water Act (CWA) 303(d) program provides a more updated and collaborative framework for more efficient implementation of the program through the states. In particular, it encourages focusing attention on priority waters and acknowledges states have flexibility in using available tools beyond Total Maximum Daily Loads (TMDLs) to attain water quality restoration and protection. In the Integrated Reporting Guidance issued in 2016, EPA acknowledges the most effective method for achieving water quality standards for some water quality impaired segments may be through controls developed and implemented in advance of a TMDL. Alternative approaches designated in the Integrated Report as sub-category 5-alt—in advance of a TMDL—recognize that an alternative restoration approach may be more effective than TMDL reports in reaching the goal of re-attaining support status for impaired waters. If an alternative restoration approach does not show progress in attaining water quality standards, the impaired segment will be reprioritized for TMDL development.

In 2015, Tennessee developed a [priority framework document](#) outlining plans to implement prioritization of alternative restoration projects. In it, Tennessee has identified HUC-12s with both nutrient-impaired streams and source water protection areas. In keeping with Tennessee's [watershed approach](#) and corresponding schedule, Tennessee considered Group 1 watersheds for alternative plans in FY-2017 and FY-2018. This report addresses Crooked Fork and Flat Fork in Subwatershed 060102080403 in the Emory River Watershed (06010208).

HUC 10	HUC 12	IMPAIRED STREAM	STREAM ID
0601020804 Emory River	060102080403 Crooked Fork Creek	Crooked Fork	TN06010208004_1000
		Flat Fork	TN06010208004_0200

Table 1. Numbers and Names of HUCs and Nutrient-Impaired Streams in the Report. HUC, Hydrologic Unit Code.

I. Nutrient-Impaired Waterbodies to be Addressed.

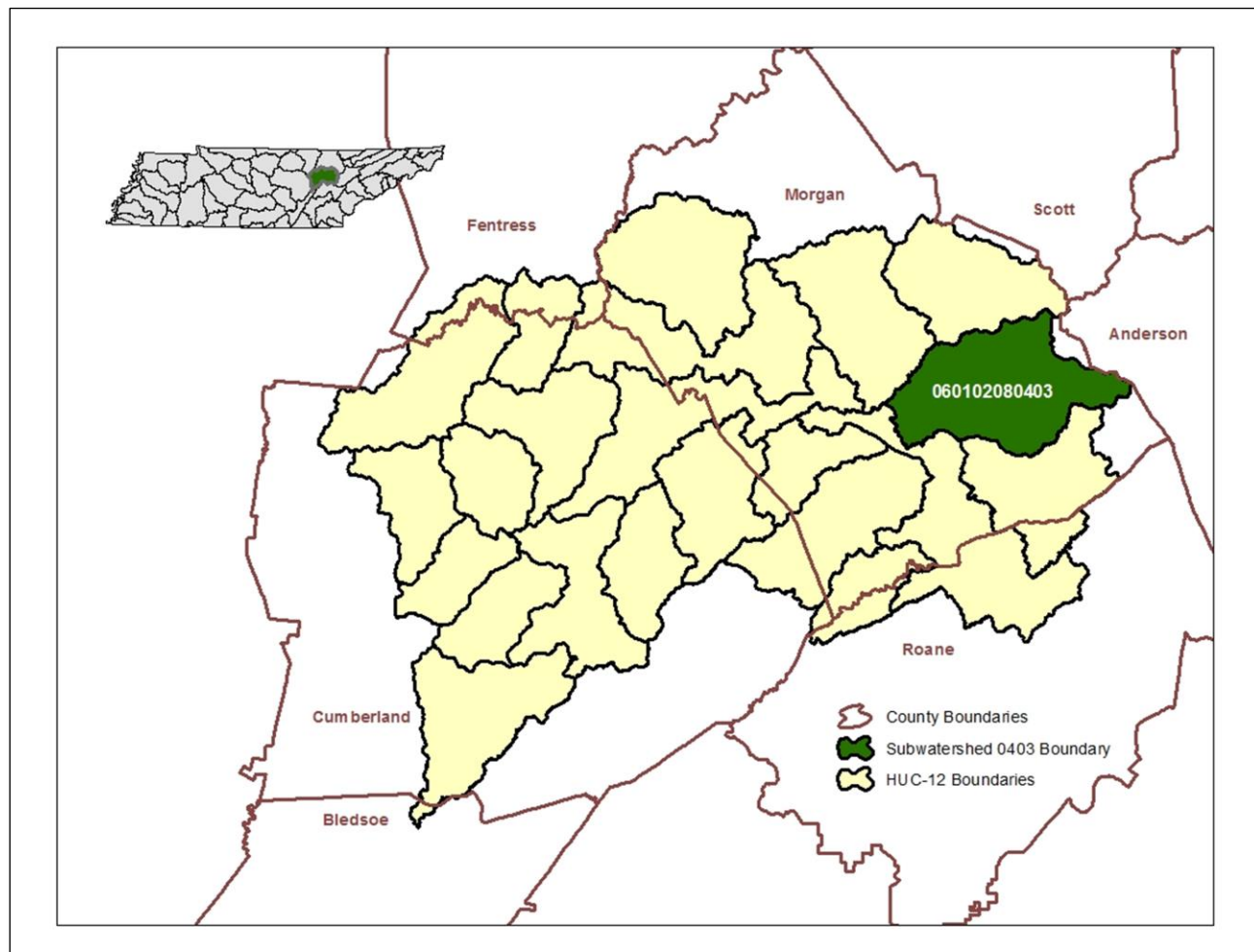


Figure 1. Location of HUC-12 Subwatershed 060102080403 in the Emory River Watershed. Subwatershed 060102080403 is Crooked Fork Creek Watershed. Both Crooked Fork and Flat Fork are within the Subwatershed 060102080403 boundary.

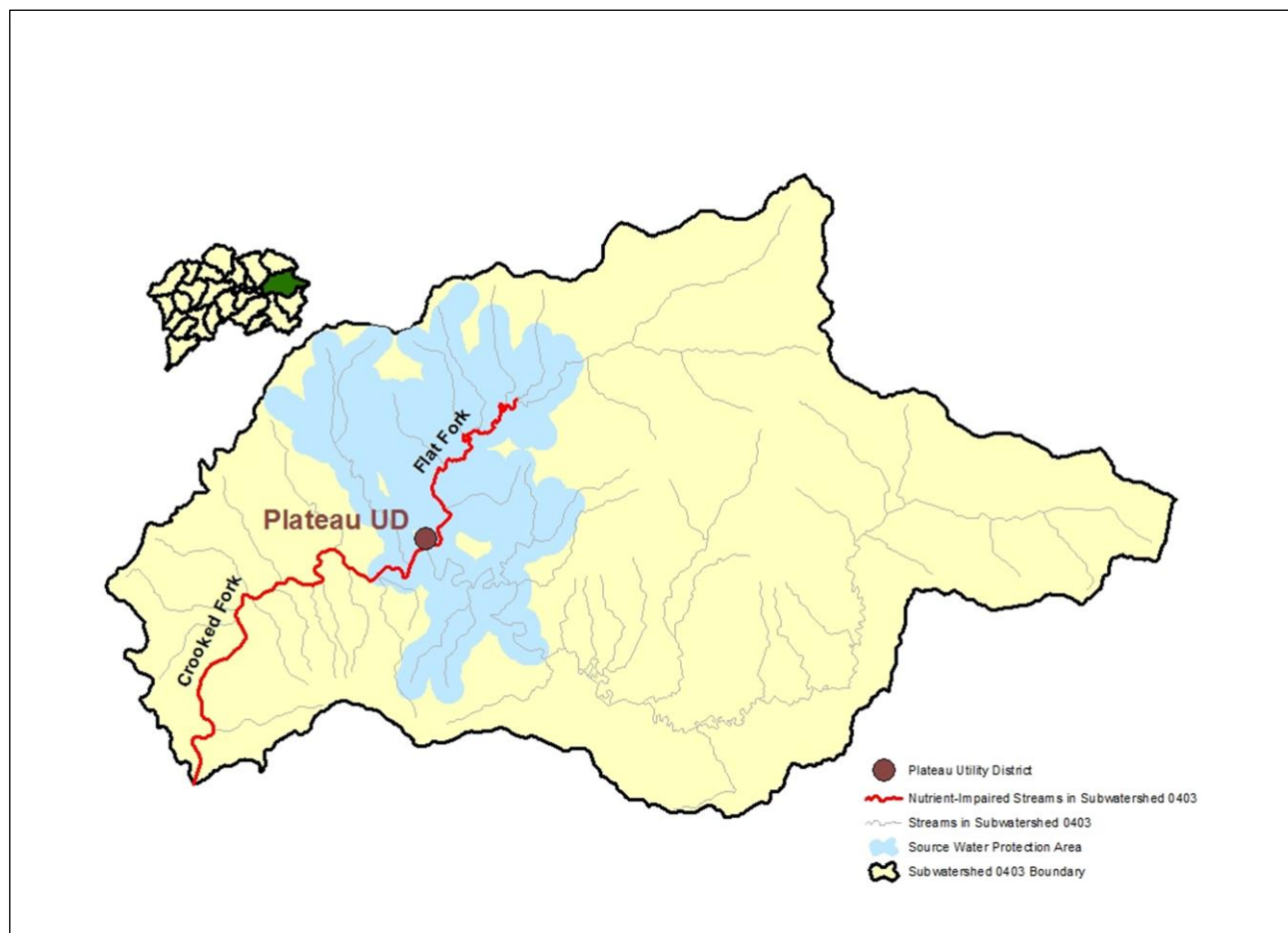


Figure 2. Illustration of Nutrient-Impaired Stream and Source Water Protection Area in HUC-12 Subwatershed 060102080403. UD, Utility District.

SEGMENT NUMBER	NAME	COUNTY	MILES	CAUSES/TMDL PRIORITY)	SOURCES
TN06010208004_0200	Flat Fork	Morgan	3.7	Sedimentation/Siltation (NA) Nitrates/Nitrite (L) Physical substrate habitat alterations (NA)	Grazing in riparian or shoreline zones Channelization
TN06010208004_1000	Crooked Fork	Morgan	6.9	Oxygen, Dissolved (L) Nitrate/Nitrite (L) Grazing in riparian or shoreline zones (L) Municipal point source discharges (L)	Municipal point source dischargers Grazing in riparian or shoreline zones

Table 2. Water Quality Descriptions of Flat Fork Creek and Crooked Fork in Subwatershed 060102080403 from Tennessee's List of Impaired Streams as of 04/01/2018. L, Low; NA, Not Applicable because a TMDL has been approved for this segment/parameter. Table 2 is the complete listing of causes of impairment for Flat Fork and Crooked Fork in subwatershed 060102080403. This 5-alt report only addresses Nitrate+Nitrite cause of impairment.

II. Action Plan that Addresses Point and Nonpoint Sources.

Tennessee is using both a point source and nonpoint source approach for addressing nutrients in the Crooked Fork Creek subwatershed. Tennessee will use the process described in the [Tennessee Nutrient Reduction Framework \(“the Framework”\)](#) to address these sources.

Point Sources. Under the Framework, planning is HUC-10-based and uses SPARROW-derived (**S**patially **R**eferenced **R**egressions **o**n **W**atershed attributes) loads to describe a process to calculate an enrichment factor (total load divided by background load) and the percent contribution by point sources. NPDES permit writers use this information when setting permit limits for nutrients.

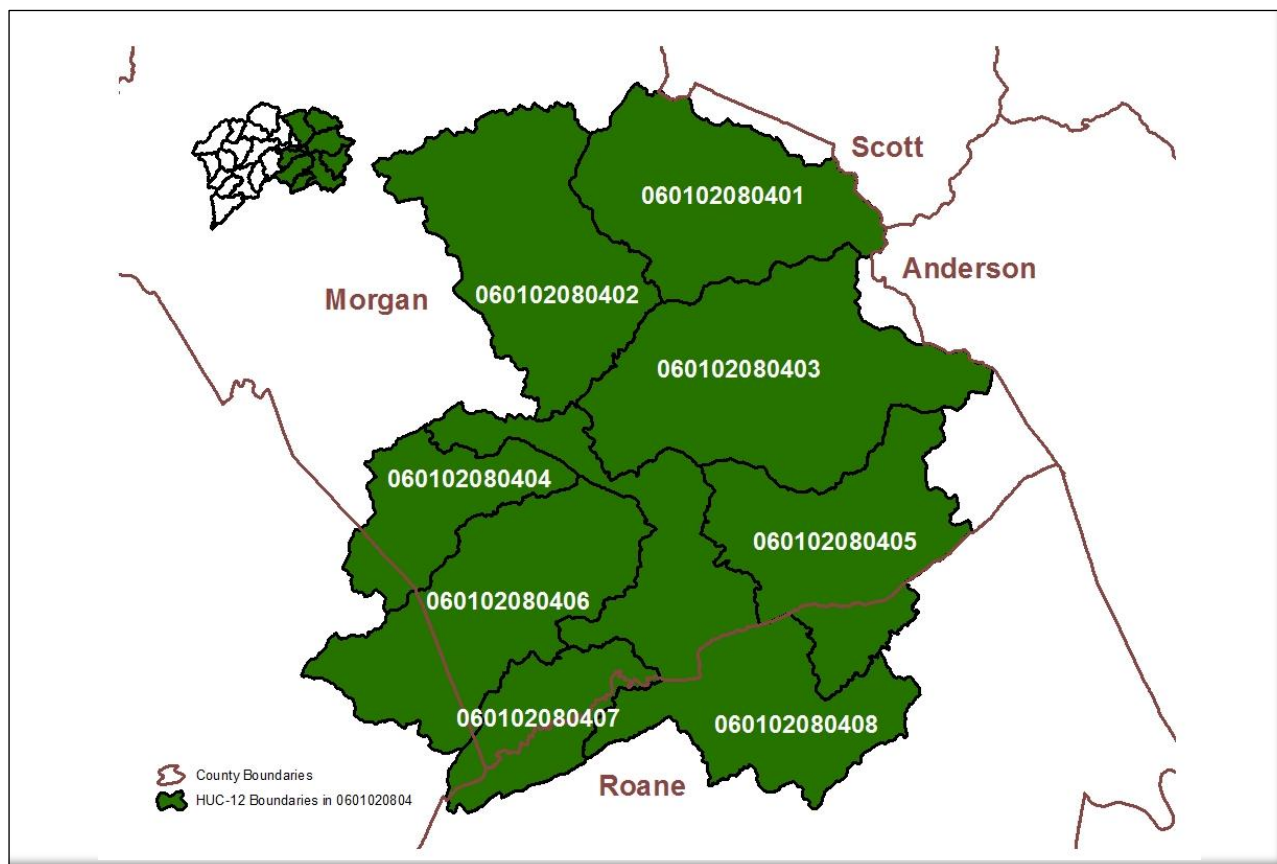


Figure 3. Location of HUC-10 Subwatershed 0601020804. Subwatershed 0601020804 is composed of eight HUC-12s.

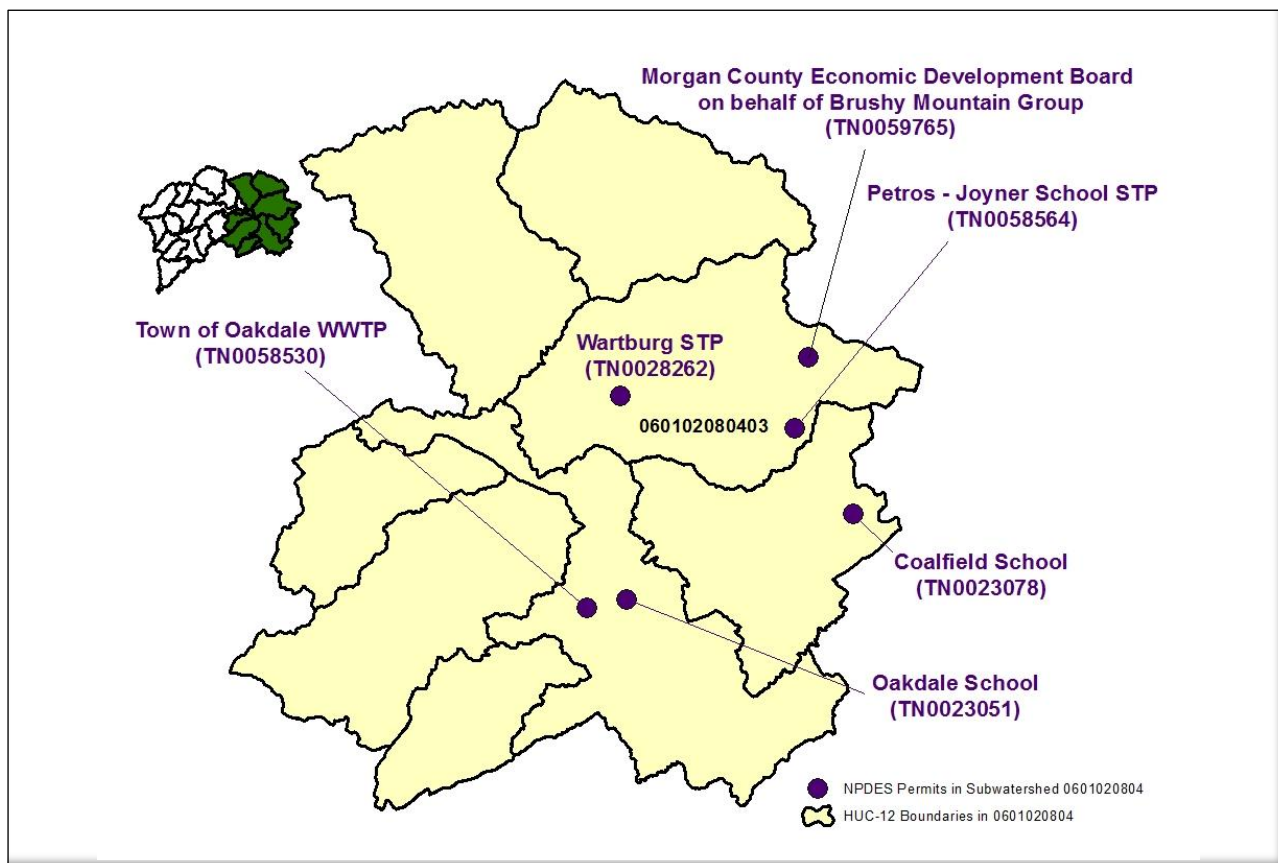


Figure 4. Illustration of NPDES Permit Locations in HUC-10 Subwatershed 0601020804. Only three NPDES permittees discharge to Subwatershed 060102080403 (TN0059765, TN0058564, and TN0028622).

Using data from the USGS SPARROW model, analysis sheets have been created for the point sources in subwatershed 0601020804 (Figures 5 and 6).

TENNESSEE SPARROW HUC10 TOTAL NITROGEN ANALYSIS SHEET

EMORY RIVER WATERSHED (HUC10: 06010208 - 04)

vs 11/9/17

SPARROW Modeled TN Load at Outlet of HUC10 (04)

Source Category	Contribution (%)
Air Deposition ("background")	75.12
Manure	8.15
Fertilizer	5.51
Urban	9.47
Wastewater	1.76
Total	100.0
Total Load	686,496 lbs/yr
Drainage Area	380 sq mi
Unit Area Load	2.821 lbs/ac/yr
Mean Annual Streamflow	1639.33 cfs

Point Source Load Contribution	Enrichment Factor		
	EF < 1.54	1.54 ≤ EF < 2.06	EF ≥ 2.06
%C ≥ 6.26%	Low	Medium	High
2.04% ≤ %C < 6.26%	Low	Medium	Medium
%C < 2.04%	Low	Low	Low

TN Enrichment Factor = $\frac{\text{Total Current Load}}{\text{Total "Background" Load}}$ = 1.33

Impact Category: Low
Expected WWTP Treatment Performance: Cap

Point Source Characteristics

Facility	Permit #	Design Flow (MGD)	Average Flow (MGD)	Ratio (Avg/Design)	Avg TN Conc (mg/L)	Recommended Reduction (%)	# of Samples	Data Source	Discharge to Nutrient Impaired Waterbody (2016)
Wartburg STP	TN0028622	0.75	0.524	69.9%	5.569	na	38	DMRs (2012-15)(dly max)	Crooked Fork Crk
Brushy Mountain STP	TN0059765	0.15	0.15		na	na	0	no DMRs available	
Petros-Joyner School STP	TN0058564	0.02	0.02		na	na	0	no DMRs available	Crooked Fork Crk
Oakdale School	TN0023051	0.018	0.018		na	na	0	no DMRs available	
Coalfield School	TN0023078	0.015	0.015		na	na	0	no DMRs available	
Oakdale Housing STP	TN0058530	0.01	0.01		na	na	0	no DMRs available	

Recommended Point Source Facility Load

Facility	Permit #	Allowable Annual Load *	Recommended Monitoring
Wartburg STP	TN0028622	8,883	monthly grab sample
Brushy Mountain STP	TN0059765	20,548	quarterly grab sample
Petros-Joyner School STP	TN0058564	2,740	quarterly grab sample
Oakdale School	TN0023051	2,466	quarterly grab sample
Coalfield School	TN0023078	2,055	quarterly grab sample
Oakdale Housing STP	TN0058530	1,370	quarterly grab sample

* Allowable Annual Load calculated based on expected treatment performance (if reduction is recommended) or monitoring data (if no reduction is recommended). In the absence of monitoring data, load is calculated from design flow and a default TN concentration of 45 mg/L.

Potential Trading Source

Ratio -- Wastewater(STP)/Wastewater(other)	
Ratio -- WWTP/(fertilizer+manure)	0.13
Ratio -- (WWTP+urban)/(fertilizer+manure)	0.82

Figure 5. Analysis Sheet for Total Nitrogen for NPDES Facilities in Subwatershed 0601020804. DMR, Discharge Monitoring Report; WWTP, Wastewater Treatment Plant; STP, Sewage Treatment Plant; MGD, Million Gallons per Day; Crk, Creek; EF, Enrichment Factor.

Based on the wastewater contribution (1.76%) and the enrichment factor (1.33), the process described in the Framework categorizes facilities in this HUC-10 as "Low" for nitrogen, indicating reductions may not be necessary.

TENNESSEE SPARROW HUC10 TOTAL PHOSPHORUS ANALYSIS SHEET											
EMORY RIVER WATERSHED (HUC10: 06010208 - 04)										vs	4/16/18
SPARROW Modeled TP Load at Outlet of HUC10 (04)											
Source Category	Contribution (%)										
Soil Parent Rock ("background")	42.3										
Mines	0.0										
Manure	5.8										
Agriculture	13.4										
Urban	35.2										
Wastewater	3.3										
Total	100.0										
Total Load	54,920	lbs/yr									
Drainage Area	380	sq mi									
Unit Area Load	0.226	lbs/ac/yr									
Mean Annual Streamflow	1639.33	cfs									
Point Source Characteristics											
Permittee	Permit #	Design Flow (MGD)	Average Flow (MGD)	Ratio (Avg/Design)	Avg TP Conc (mg/L)	Recommended Reduction (%)	# of Samples	Data Source		Discharge to Nutrient Impaired Waterbody (2016)	
Wartburg STP	TN0028622	0.75	0.524	69.9%	2.552	cap	39	DMRs (2012-15)(dly max)		Crooked Fork Crk	
Brushy Mountain STP	TN0059765	0.15	0.15		na	na	0	no DMRs available			
Petros-Joyner School STP	TN0058564	0.02	0.02		na	na	0	no DMRs available		Crooked Fork Crk	
Oakdale School	TN0023051	0.018	0.018		na	na	0	no DMRs available			
Coalfield School	TN0023078	0.015	0.015		na	na	0	no DMRs available			
Oakdale Housing STP	TN0058530	0.01	0.01		na	na	0	no DMRs available			
Recommended Point Source Facility Load											
Facility	Permit #	Allowable Annual Load **			Recommended						
Wartburg STP	TN0028622	4,071			monthly grab sample						
Brushy Mountain STP	TN0059765	2,283			quarterly grab sample						
Petros-Joyner School STP	TN0058564	304			quarterly grab sample						
Oakdale School	TN0023051	274			quarterly grab sample						
Coalfield School	TN0023078	228			quarterly grab sample						
Oakdale Housing STP	TN0058530	152			quarterly grab sample						
* Allowable Annual Load calculated based on expected treatment performance (if reduction is recommended) or monitoring data (if no reduction is recommended). In the absence of monitoring data, load is calculated from design flow and a default TP concentration of 5 mg/L.											
Potential Trading Source											
Ratio -- Wastewater(STP)/Wastewater(other)											
Ratio -- WWTP/(ag+manure)		0.17									
Ratio -- (WWTP+urban)/(ag+manure)		2.01									

Figure 6. Analysis Sheet for Total Phosphorus for NPDES Facilities in 0601020804. DMR, Discharge Monitoring Report; WWTP, Wastewater Treatment Plant; STP, Sewage Treatment Plant; MGD, Million Gallons per Day; Crk, Creek; EF, Enrichment Factor. This information is presented for informational purposes only. Neither Flat Fort nor crooked Fork is impaired for phosphorus.

Based on the wastewater contribution (3.3%) and the enrichment factor (2.36), the process described in the Framework categorizes facilities in this HUC-10 as "LOW" for phosphorus, indicating reductions may not be necessary.

These analysis sheets act as a decision matrix and help permit writers establish nutrient limits based on 1) enrichment factors and 2) percent contribution in the watershed using the process described in the Framework. The analysis sheets indicate the trading potential between point and nonpoint sources, which TDEC is in the early stages of exploring. In support of that, TDEC has secured a grant from the Tennessee Valley Authority (TVA) to explore the feasibility of trading in the Tennessee Valley.

There are three NPDES facilities that discharge within the Crooked Fork Creek Subwatershed.

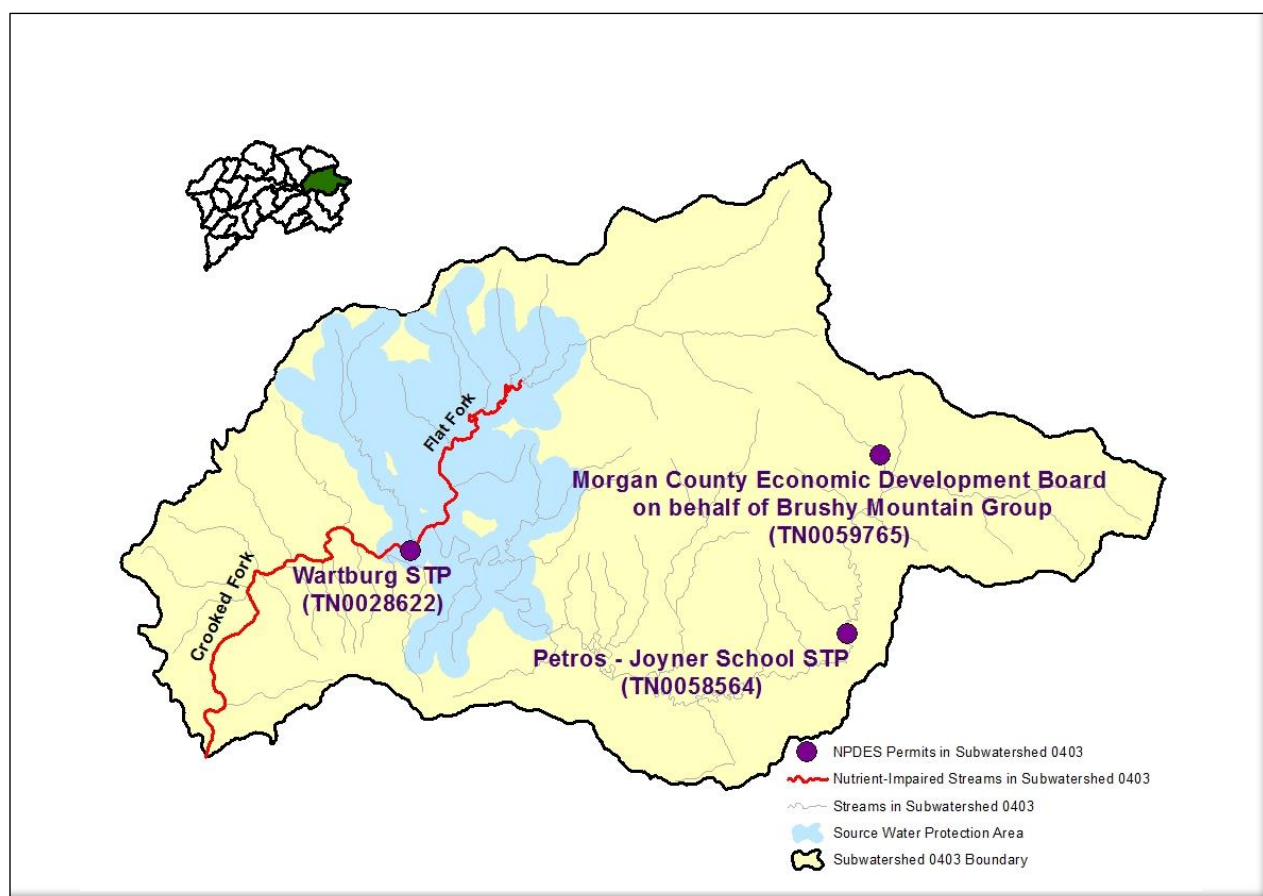


Figure 7. Illustration of Nutrient-Impaired Streams, Source Water Protection Area, and NPDES Facilities in HUC-12 Subwatershed 060102080403. TN0028622 (Wartburg STP) discharges to Crooked Fork at RM 6.3. TN0058564 (Petros-Joyner School STP) discharges to Crooked Fork at RM 16.1. TN0059765 (Brushy Mountain Group) discharges to Stockstill Creek at RM 1.5. STP, Sewage Treatment Plant.

Petros-Joyner School is a minor discharger, so under Tennessee’s Framework is not being considered for revised permit limits. The remaining two permits will expire in 2021 and the SPARROW Analysis sheets will be used to establish nitrogen and phosphorus limits. Currently, nitrogen and phosphorus requirements are:

PERMIT NUMBER	PERMITTEE	NITROGEN	PHOSPHORUS
TN0028622	Wartburg STP*	22,110 lb/yr	Report Only
TN0059765	Brushy Mountain Group**	Report Only	Report Only

Table 3. Summary of Nitrogen and Phosphorus Requirements for Select NPDES Facilities in HUC 12-Subwatershed 060102080403. Only Wartburg STP discharges to a nutrient-impaired stream. *Sample Type: Composite; Frequency: Monthly; Statistical Base: Rolling Average; **Sample Type: Composite; Frequency: Quarterly; Statistical Base: Quarterly Maximum.

In addition, Tennessee is always evaluating if a facility would be a good candidate for plant optimization, the process by which waste water treatment plants develop standard operating procedures for optimizing nitrogen removal, phosphorus removal, and energy consumption. Tennessee has undergone two rounds of plant optimization and plans to continue encouraging WWTPs to use this nutrient reduction approach. The Wartburg STP has had a recent history of compliance issues, but is now on track to meet permit limits. After a new base line is set, Wartburg will be considered for plant optimization. The Brushy Mountain Group facility is now a mixed use development (formerly a prison). When they were designing the upgrade, they included biological nutrient removal.

Nonpoint Sources. In rural areas of Tennessee, excess nutrients in streams are frequently due to several agricultural practices (mostly poor pasture management and livestock access to the stream) and failing septic systems. Proper pasture management has been known to improve water quality for some time. In the USDA publication “Nutrient Management in Pastures and Haylands,” authors Wood, *et al.* argue for the judicious use of nutrients in managing the nation’s pastures and haylands.

The Land and Water Stewardship Section (LWSS) within the Tennessee Department of Agriculture, administers the Section 319 Nonpoint Source Program and the state-funded Agricultural Resources Conservation Fund Program to assist landowners who wish to install Best Management Practices (BMPs). In the Emory River’s Crooked Fork Creek Subwatershed 060102080403, practices installed by stakeholders were all United States Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS)-approved practices designed to reduce sediment and nutrients.

Four grants totaling \$914,000 have been awarded in this watershed. The initial 319-funded Crooked Fork Restoration project has focused on education, partnership development, and planning. The work on the ground was organized and led by the Morgan County Soil Conservation District after consultation with The Tennessee Department of Agriculture and funded through a FY-2007 grant. The funded grant proposal stated that the objective of the project was “to restore Crooked Fork and Flat Fork to fully support their designated uses by working with private and public landowners.” The restoration plan is built upon the approved siltation and habitat alteration TMDL for the Emory River (approved by EPA in 2006) with the understanding that controlling the movement of sediment will also contribute to controlling nutrients.

The project built upon prior activities in the subwatershed:

- A 319 grant-funded participatory process to train local volunteers to visually assess Crooked Fork Creek Subwatershed
- Completed Crooked Fork Creek subwatershed Visual Assessment project
- Analyses of chemical/physical data by University of Tennessee graduate students
- Development and update of land cover layer and pollutant load model to estimate loads
- Ongoing education and outreach including brochures, watershed tours, river festivals, displays, Kids in the Creek events, and volunteer training classes
- Hornyhead Branch (a tributary of Crooked Fork) restoration project, which won the 2006 Governor's Environmental Stewardship Award in the Agriculture/Forestry Division
- Annual riparian buffer and plant distribution project which has distributed over 10,000 native riparian seedlings and information about stream buffers to over 200 Crooked Fork Watershed residents
- Multiple presentations, meetings, and newspaper articles about Crooked Fork Creek subwatershed

COOPERATOR	ROLE IN PROJECT
Emory River Watershed Association	Monitoring, sample collection, community outreach, education
Morgan County Schools	Volunteers, tree planting, revegetation
USDA-NRCS	Technical assistance, leveraged funds from Farm Bill Conservation Title programs
Cumberland Mountain RC&D Council	Technical assistance
Tennessee Department of Agriculture	Technical assistance and Financial assistance
Tennessee Department of Environment and Conservation	Technical assistance
University of Tennessee Extension	Technical assistance
University of Tennessee Forest Research and Education Center	Education and outreach
Tennessee Valley Authority	Staff time, education material development, technical assistance, monitoring

Table 4. BMP Partners and Their Roles in the Morgan County Soil Conservation District Flat Fork/Crooked Fork Project. BMP, Best Management Practice, RC&D, Resource Conservation and Development, NRCS, Natural Resources Conservation Service.

The following milestones were met by the Morgan County Soil Conservation Project Partners in Crooked Fork Creek Subwatershed, and many of their goals were exceeded:

- Create one brochure, submit one newspaper article, conduct one public meeting, and develop one landowner mailing list (six months)
 - Newspaper article submitted on 11/15/2007
 - Public meeting held on 12/1/2007
 - Landowner mailing list developed 11/15/2007
 - One newsletter developed and mailed on 11/19/2007
- Complete 100 acres of pasture package improvements (12 months)
 - 203.8 Acres of Pasture Renovation completed by 4/25/2008
- Mail one additional newsletter (18 months)
 - Additional newsletter mailed 5/2/2008
 - Farm Tour conducted 5/20/2008
- Complete 125 acres of pasture package improvements, restore 10 acres of barren land or mine land, and develop and mail one newsletter (24 months)
 - Completed Hayland Renovation (38.1 Acres)
 - Completed eight septic system repairs/replacements (8 Acres)
- Host one public outreach event, develop and mail one newsletter (24 months)
 - Additional newsletter mailed 4/2/10
 - Maintained a booth with Crooked Fork Watershed handout material at Discovery Fest 4/17/2010
- Complete additional 125 acres of pasture package improvements, restore 10 acres of barren land or mine land, and develop and mail one newsletter (36 months)
 - Completed Hayland Renovation (8 acres) 5/7/2010
 - Completed Hayland Renovation (8.1 acres) 5/8/10
 - Completed Hayland Renovation (23.1 acres) 4/7/2010
 - Completed Hayland Renovation (32 acres) 09/23/2010
 - Completed Hayland Renovation (70 acres) 09/16/2010
 - WECO (call letters for a local radio station) Outdoor Show July 16-17, 2010
 - Crooked Fork Tour 09/18/2010
 - Crooked Fork Tour Outreach Newsletter 09/18/2010
 - WECO Radio Advertising September 2010 (30 days) and October 2010 (31 days)
 - Crooked Fork Outreach Letters 10/06/2010 for Clean Up Project at Potters Falls

- Host one farm tour and develop and mail one newsletter (42 months)
 - Litter Pickup on Laymance Falls in Crooked Fork Watershed 11/06/2010
 - WECO Radio Advertising August 2010 – May 2011
 - Crooked Fork Outreach Newsletters for Farm Tour
 - Field Day for Herbicide Training – Farm Tour - 03/15/2011
 - Kids in the Creek – at Frozen Head State Park 05/10/2011
- Complete 125 acres of pasture package improvements, restore 10 acres of barren land or mine land, and develop and mail one newsletter (48 months)
 - Completed Hayland Renovation on (64 acres) 3/29/2011
 - Completed Hayland Renovation (8 acres) 3/30/2011
 - Completed Hayland Renovation (70 Acres) 4/4/2011
 - Completed twenty-four Septic System Repairs (24 acres)
- Host one public outreach event and develop and mail one newsletter (54 months)
 - Purchased and distributed caps and hats for advertisements 11/2011 to 10/2012
 - Kids In The Creek Enviroscape Presentation May 10, 2012
 - WECO Outdoor Show July 16-17, 2012
 - “Ruby The Raindrop” and Earth Team Volunteers Present program on Water Quality and Soil Erosion at Wartburg Central Elementary School to 300 students. October 10, 2012
 - Awards Picnic October 18, 2012
- Complete 177 acres of pasture package improvements and 10 acres of barren land or mine land restored, develop and mail one newsletter, and conduct physical/chemical and benthic macroinvertebrate monitoring to assess results (60 months).
 - Completed 35 septic system repairs 35 Acres 11/9/2011 to 10/11/2012
 - Completed 46 acres of Pasture Planting 10/17/2011
 - Completed 200 feet of Stream bank Stabilization- 10/27/2011
 - Completed 6.3 acres of Exclusion Fence 8/3/2011
 - Completed 1 Stream Crossing 8/26/2011
 - Completed 9.2 acres of Pasture Planting 8/26/2011
 - Completed 100 Acres of Pasture and Hay land planting along with 100 acres of nutrient management 3/24/2012
 - Completed 1 Tailwater Recovery System-8 Acres 5/21/2012
 - Completed seeding (8 Acres) 9/11/2012
 - Heavy Use Area (70 Acres) 9/12/2012
 - Completed 3 Heavy Use Areas (100 Acres) 10/29/2012
 - Acreage improved with Septic Repair/Replacement (5 acres)

According to the final report submitted by the Morgan County Soil Conservation District, the total area improved by BMP's within the subwatershed during the contract period was 952 acres, which far exceeded the project goal of 652 acres. Landowners who had septic systems in the watershed which were contributing to high levels of raw sewage discharge (E. coli and nutrients) were very interested in repairing these as well. When cost-share dollars were made available to them they were very appreciative. Many of the septic system repairs were on land which was farmed, thus providing additional improvement of farm land as well. This project was very successful in the

number of acres impacted and much appreciated by the citizens of Morgan County. There was a great response from homeowners who were pleased and appreciative for the help they received in repairing or replacing faulty septic systems. Most of them would never have been able to afford these repairs without this grant. A total of 952 acres of land impacting 303(d)-listed Crooked Fork and its tributaries was improved.

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Pasture Improvement					
Mine Land Reclamation					
Barren Land Reclamation					
Waste Issues Study					
Channelized Stream Study					
Deep Mine Study					
WQ/Benthic Monitoring					
Adaptive Management Planning					
Educational Outreach (newsletters, brochures, farm tours, riparian plant buffer project)					

Table 5. Activities by the Morgan County Soil Conservation District Partners in Crooked Fork Creek SubWatershed from 2007-2011.

BEST MANAGEMENT PRACTICE	TOTAL NUMBER IMPLEMENTED	YEARS IMPLEMENTED
Alternate Septic System	1	2016
Fence	1	2011
Nutrient Management	11	2008-2011
Pasture/Hayland Planting/Restoration	20	2008-2016
Septic System Repairs	114	2007-2017
Limited Stream Access	1	2011
Stream Bank Protection	4	2011-2014

Table 6. BMP Practices Funded by Tennessee Department of Agriculture in HUC-12 Subwatershed 060102080403 Within the Emory River HUC-8 Watershed.

BEST MANAGEMENT PRACTICE	TOTAL ACRES IMPLEMENTED	YEARS IMPLEMENTED
Cover Crop	11.6	2007
Prescribed Grazing	152	2008-2009
Nutrient Management	161.6	2007-2012

Table 7. BMP Practices Funded by USDA-NRCS in HUC-12 Subwatershed 0601402080403 Within the Emory River Watershed. Only BMPs known to improve water quality are shown.

Before



After



Pasture Renovation



Hayland Seeding

Before



After



Stream Bank Restoration

The 319 program funded a follow-up project by the Morgan County Soil Conservation District in FY-2013. (12/1/2013 through 7/31/2017). The stated goal(s) were to “restore Crooked Fork, Mud Creek, and Flat Fork to fully support their designated uses” by working with private landowners.

COOPERATOR	ROLE IN PROJECT
Emory River Watershed Association	Community outreach, education
Morgan County Schools	Volunteers
USDA-NRCS	Technical assistance, leverage funds for BMPs through Farm Bill Conservation Title programs
Cumberland Mountain RC&D Council	Technical assistance
Tennessee Department of Agriculture	Technical assistance, matching funds through the Agricultural Resources Conservation Fund
Morgan County Forestry Association	Community Outreach
University of Tennessee Extension	Technical assistance, community outreach
Tennessee Valley Authority	Technical assistance

Table 8. BMP Partners and Their Roles in the Morgan County Soil Conservation District Flat Fork/Crooked Fork Project. BMP, Best Management Practice, RC&D, Resource Conservation and Development, USDA-NRCS, Natural Resources Conservation Service.

The project built upon successful prior activities in the subwatershed:

- A 319 grant-funded participatory process to train local volunteers to visually assess Crooked Fork Creek Watershed
- Completed subwatershed visual assessment project
- Analyses of chemical/physical data by University of Tennessee graduate students
- Development and updated land cover layer and pollutant load model to estimate loads
- Ongoing education and outreach activities including brochures, watershed tours, river festivals, displays, Kids in the Creek events, and volunteer training classes
- Hornyhead Branch (a tributary of Crooked Fork) restoration project, which won the 2006 Governor’s Environmental Stewardship Award in the Agriculture/Forestry Division
- Annual riparian buffer and plant distribution project which has distributed over 10,000 native riparian seedlings and information about stream buffers to over 200 Crooked Fork Watershed residents
- Multiple presentations, meetings, and newspaper articles about Crooked Fork Watershed

The implementation schedule was designed to include 3 years of on the ground pasture improvement, including stream bank and buffer improvement.

	YEAR 1	YEAR 2	YEAR 3
Pasture improvement and septic repairs			
Mine land reclamation			
Barren land reclamation			
Educational outreach: (newsletters, brochures, farm tours, free classes, riparian plant buffer project)			

Table 9. Activities by the Morgan County Soil Conservation District Partners in Crooked Fork Watershed from 2007-2011.

The Morgan County Soil Conservation District set out to perform outreach to landowners through newsletters, farm tours, calendars, brochures, newspaper articles, free training classes, UT Extension Service and USDA-NRCS/Morgan County Soil Conservation District Office and by word of mouth regarding the availability of cost-share dollars at a competitive cost-share rate. In order to do this, they set these milestones (and accomplished these results):

- Write one brochure and one newspaper article, conduct one public meeting, develop/update a landowner mailing list, and write/mail one newsletter (6 months)
 - A brochure was not developed in lieu of flyers and use of news articles to promote the grant. Postcards were developed and sent to landowners with 319 project information on April 4, 2014
- Complete 100 acres of pasture package improvements (12 months)
 - 100 acres of pasture package was not completed within the 12 months of the contract start date because of a slow time during the first 3 months (Jan-March). Nevertheless, from March 11th, 2014-November 21st, 2014 - 52 BMP's were completed
- Mail an additional newsletter and conduct one farm tour (18 months)
 - Newsletters were submitted highlighting 319 grant-funded Crooked Fork completed practices and outcomes from the 319 community outreach meeting. A farm tour was not conducted because the board decided in favor of an outreach meeting
- Complete 125 acres of pasture package improvements and restore five acres of barren land or mine land, and write/mail one newsletter (24 months)
 - During the 24 months of contract start date, 77 BMP's were completed but there were no barren or mine lands restored (mostly septic systems and seeding)
- Host one public outreach event and develop/mail one newsletter (30 months)
 - Hosted an outreach meeting on July 22, 2014 and promoted the event by flyers and radio advertising
- Complete 125 acres of pasture package improvements and restore 10 acres of barren land or mine land (36 months)
 - During the 24 months after contract start date, 77 BMP's were completed but there were no barren land mine restored, mostly just septic system repairs and seeding

Additional accomplishments of the Morgan County Soil Conservation District were:

- Met with Morgan County School superintendent about stream bank work (March 2014)
- Site visits to eleven project applicants (June 2014)
- Placed full page ad in newspaper for community outreach meeting (July 2014)
- Community outreach meeting/dinner (July 2014)
- Distributed brochures at a booth for WECO Outdoor Show (July 2014)
- Sale of public awareness T-shirts (August 2014)
- Community meeting at stream bank restoration site (October 2014)
- Newspaper article and annual report featuring Crooked Fork stream bank project (September 2014)
- Distributed hats and T-shirts at a booth for WECO Outdoor Show (July 2015)
- Hosted Christmas event for county commissioners while promoting Crooked Fork through Powerpoint presentations and display board (December 2015)
- Distributed brochures at a booth for WECO Outdoor Show (July 2016)
- Hosted Christmas event for Farm Bureau and landowners while promoting Crooked Fork through Powerpoint presentations and brochures (December 2016)



Septic Repair/Replacement



Pasture/Hayland Renovation

Before



After



Sreambank Stabilization



Outreach

The total area improved by BMPs within the watershed during the contract period was 183 acres, which included 30 acres of septic system repairs, 108 acres of pasture and hay land , and 25 acres of streambank restoration. Most of the landowners who had septic system repairs through this project reported that they would never have been able to afford these repairs without this grant.

The 319 program recently funded another application by the Morgan County Soil Conservation District (FY-2016). The grant application identifies successful prior work that they will build upon:

- Implemented a 319 grant-funded participatory process to train local volunteers to assess Crooked Fork Watershed to support development of this watershed restoration plan (the current proposal)
- Completed a subwatershed visual assessment project
- On-going education and outreach including brochures, watershed tours, river festivals, displays, Kids in the Creek events, and volunteer training classes
- Annual riparian buffer and plant distribution project (over 10,000 native riparian seedlings have been distributed since 2003) and information distributed to over 200 Crooked Fork Watershed residents
- Multiple presentations, meetings, and newspaper articles about Crooked Fork Watershed, stream conditions, and possible management options

COOPERATOR	ROLE IN PROJECT
Emory River Watershed Association	Community outreach, education
Morgan County Schools	Volunteers
USDA-NRCS	Technical assistance, leveraged funds for BMPs through the Farm Bill Conservation Title programs
Cumberland Mountain RC&D Council	Technical assistance
Tennessee Department of Agriculture	Technical assistance, matching funds through the Agricultural Resources Conservation Fund
Morgan County Forestry Association	Community Outreach
University of Tennessee Extension	Technical assistance, community outreach
Tennessee Valley Authority	Technical assistance

Table 10. BMP Partners and Their Roles in the Morgan County Soil Conservation District Flat Fork/Crooked Fork Project. BMP, Best Management Practice, RC&D, Resource Conservation and Development, USDA-NRCS, Natural Resources Conservation Service.

Once again, the Morgan County Soil Conservation District restoration plan is built upon the approved siltation and habitat alteration TMDL for the Emory River Watershed (approved by EPA in 2006) with the understanding that controlling the movement of sediment will also help control nutrients. Recommendations from the TMDL that are in the restoration plan include advocacy of agricultural BMPs among landowners that will also reduce nutrient runoff:

- Riparian buffers
- Animal waste management systems
- Waste utilization
- Stream stabilization
- Fencing
- Heavy use area treatment protection
- Livestock exclusion
- Septic system repairs

	YEAR 1	YEAR 2	YEAR 3
Pasture improvement and septic system repairs			
Mine land reclamation			
Barren land reclamation			
Educational outreach: (newsletters, brochures, presentations, riparian plant buffer project)			

Table 11. Proposed activities by the Morgan County Soil Conservation District Partners in Crooked Fork Watershed for 2016-2019.

The Morgan County Soil Conservation District plans to reach out to landowners through 1) newsletters, 2) presentations, 3) calendars, 4) brochures, 5) newspaper articles, 6) UT Extension Service, 7) USDA-NRCS/Morgan County Soil Conservation District Office, and 8) by word of mouth regarding the availability of cost-share dollars at a competitive cost-share rate.

The following milestones have been set in the newest proposal:

- One brochure developed and one newspaper article submitted, one public meeting held, landowner mailing list developed, and one newsletter developed and mailed (6 months)
- Complete 100 acres of pasture package improvements (12 months)
- Mail one additional newsletter and conduct one farm tour (18 months)
- Complete 125 acres of pasture package improvements, restore five acres of barren or mine lands, and develop/mail one newsletter (24 months)
- Host one public outreach event and develop/mail one newsletter (30 months)
- Complete 125 acres of pasture package improvements and restore 10 acres of barren or mine lands, and develop/mail one newsletter (36 months)

The measures of success set out in the grant include improvements in benthic community scores and an increase in the number of stream miles that have been improved to fully supporting.

The Morgan County Soil Conservation District and the USDA-NRCS continue to request eligible projects for funding.

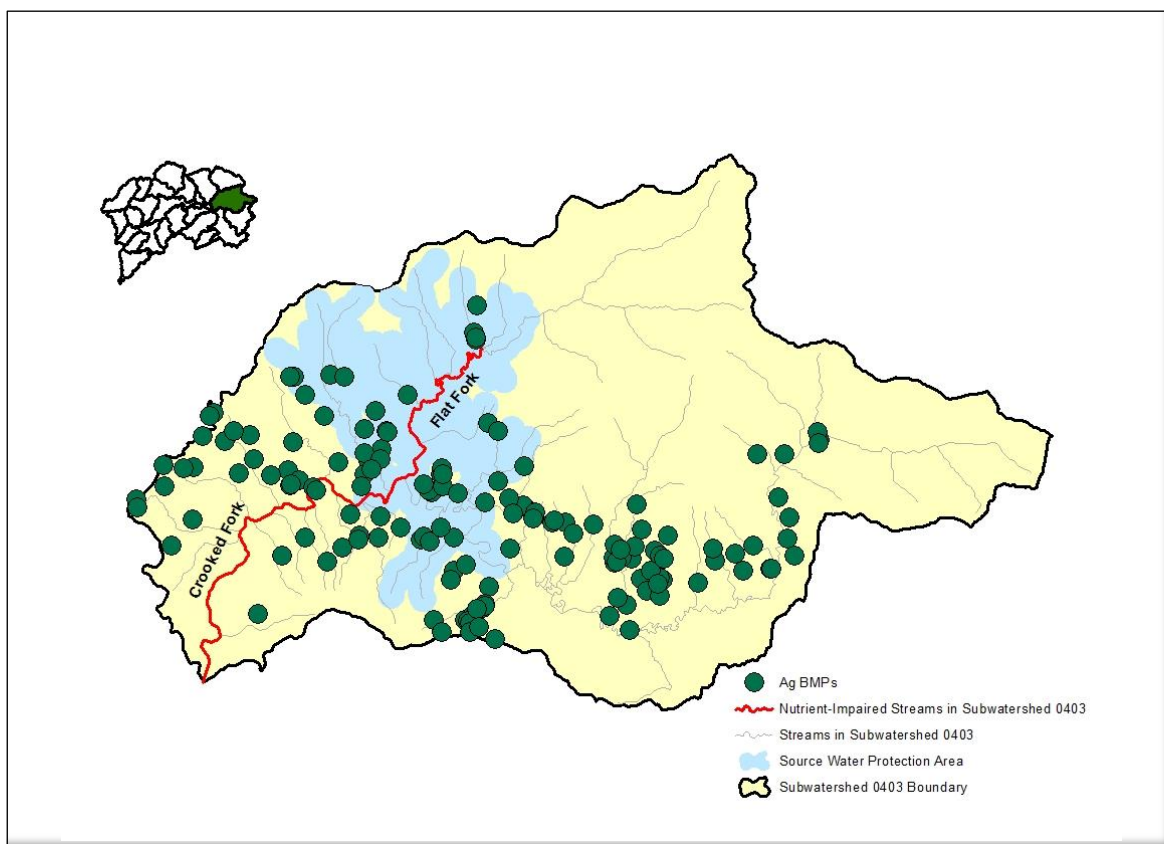


Figure 8. BMPs Installed in Crooked Fork HUC-12 Subwatershed 060102080403 with Tennessee Department of Agriculture Funds from 2003 to 2017. There are 164 BMPs installed using 319 or state (Agricultural Resource Conservation) funds from 2004 through 2017. USDA-NRCS has installed at least an additional 325 acres of BMPs in these subwatersheds between 2007 and 2012. BMP, Best Management Practice, USDA-NRCS, Natural Resource Conservation Service. Ag, Agriculture; BMP, Best Management Practice.

The Tennessee Department of Agriculture has run EPA's STEP-L spreadsheet tool for BMPs implemented as part of 319 and Agricultural Resource Conservation Funds in Subwatershed 060102080403.

RUNOFF REDUCTIONS DUE TO BMPs		
Nitrogen	Phosphorus	Sediment
18,786 lbs/yr	2,283.9 lbs/yr	907.2 tons/yr

Table 12. Nitrogen, Phosphorus, and Sediment Reductions due to BMPs Calculated Using EPA STEP-L Model. Additional reductions due to USDA-NRCS-implemented BMPs are not shown.

The Emory River Watershed Association project received a \$30,000 award in 2004 from the 319 program (this is distinct from their work with the Morgan County Soil Conservation District). In their application, the association proposed to coordinate community efforts to improve water quality of Crooked Fork from its headwaters to Emory River by achieving three goals:

1. Hold regularly scheduled meetings with stakeholders to create new partnerships, strengthen existing partnerships and to foster greater trust, commitment and accountability
2. Restore all waters impaired by nonpoint sources that are listed on the 1998 303(d) List to the condition of fully supporting their designated uses by 2015, in cooperation with local, state and federal partners
3. Improve the local knowledge of stakeholders and citizens concerning the origins, magnitude, and prevention of nonpoint source pollution.

Crooked Fork is of local significance to the residents of Morgan County because 1) it has two popular waterfalls and 2) it flows into the Emory River, which is a locally-valued part of the federal Wild and Scenic River system. Because of the familiarity and appreciation for the water resource, the Emory River Watershed Association reported that they were able to “work with an informed and motivated community with an organizational basis for positive and sustained action” and that “...this led to an organized and engaged community/stakeholder team.”

In order to complete the work, the Emory Watershed Association built a coalition of partners:

1. Tennessee Valley Authority
2. TDEC/Division of Water Pollution Control (now Division of Water Resources)
3. UT Water Resources Research Center
4. UT Biosystems Engineering Department
5. USDA-NRCS (Morgan County)
6. City of Wartburg
7. Tennessee Clean Water Network
8. Morgan County Chamber of Commerce
9. Tennessee Citizens for Wilderness Planning
10. Tennessee Department of Agriculture-Forestry Division

The 319 program continues to fund projects in Crooked Fork HUC-12 Subwatershed. The next project submittal deadline is December 1, 2018.

III. Nonpoint Source Funding Opportunities and Commitment of Partners.

Project funding was through three grants to the Morgan County Soil Conservation District and one grant to the Emory River watershed Association.

Morgan County Soil Conservation District budget grant #1 (10/31/2012-11/01/2017):

ITEM	DIRECT	MATCH	TOTAL
Salaries	\$10,000	\$11,835	\$21,835
Professional Fees/Grant Awards	\$390,000	\$345,075	\$735,075
Supplies		\$15,000	\$15,000
Printing and Publications		\$3,900	\$3,900
TOTAL	\$400,000	\$375,810	\$775,810

Table 13. Budget for Morgan County Soil Conservation District Crooked Fork Project #1. In this report, line items are omitted if no money was requested.

Match sources for Morgan County Soil Conservation District Crooked Fork Project #1:

- Emory River Watershed Association
- Local Landowners
- Local Volunteers
- Morgan County Government
- Morgan County Soil Conservation District
- Tennessee Department of Agriculture, Agriculture Resources Program
- Tennessee Department of Environment and Conservation /Division of Water Pollution Control
- Tennessee Valley Authority
- University of Tennessee Extension

Additional contributing partner:

- USDA-NRCS (Federal leveraged Funds for BMPs through the Farm Bill Conservation Title programs.)

Morgan County Soil Conservation District budget grant #2 (12/01/2013-07/31/2017):

ITEM	DIRECT	MATCH	TOTAL
Salaries	\$34,500	\$17,250	\$51,750
Professional Fees/Grant Awards	\$200,000	\$60,000	\$260,000
Supplies	\$11,500	\$9,000	\$20,500
Travel, Conferences, Meetings	\$6,000	\$1,000	\$9,000
Insurance		\$100	\$100
Capital Purchase	\$8,000	\$1,000	\$9,000
TOTAL	\$260,000	\$88,350	\$348,350

Table 14. Budget for Morgan County Soil Conservation District Crooked Fork Project #2. In this report, line items are omitted if no money was requested.

Morgan County Soil Conservation District budget grant #3 (11/01/2016-10/31/2019):

ITEM	DIRECT	MATCH	TOTAL
Salaries	\$29,928	\$17,250	\$51,750
Professional Fees/Grant Awards	\$174,000	\$50,000	\$224,000
Supplies	\$10,572	\$4,000	\$14,572
Travel, Conferences, Meetings	\$5,500	\$1,000	\$6,500
Insurance		\$100	\$100
Capital Purchase	\$4,000	\$1,000	\$5,000
TOTAL	\$224,000	\$73,350	\$301,922

Table 15. Budget for Morgan County Soil Conservation District Crooked Fork Project #3. In this report, line items are omitted if no money was requested.

Summary of funding by the Tennessee 319(h) Program (Direct Costs):

2004: Emory River Watershed Association – Crooked Fork Restoration - \$30,000
2007: Morgan County SCD – Crooked Fork Restoration - \$400,000
2013: Morgan County SCD – Crooked Fork Restoration - \$260,000
2016: Morgan County SCD – Crooked Fork Restoration – \$224,000

IV. Date When Water Quality Standards are Expected to be Achieved.

According to our watershed approach schedule, water quality assessment for the Emory River Watershed, which includes the Crooked Fork Creek HUC-12 subwatershed, is scheduled for fall 2018. Comments from the most recent assessment of Crooked Fork (2013) include that “the stream appears to have improved.” The TMI was 36 (32 is passing), but nutrients were high and algae present. Nutrient-tolerant macroinvertebrates were 11.8%, which is low for this ecoregion. The Crooked Fork project is ongoing and many BMPs were recently installed. Nevertheless, 2018 biological data (at one site) and chemical data (at all sites) show improvement (see Effectiveness Monitoring section). Crooked Fork may come off the list of impaired waters as early as the next Group 1 assessment (2019).

Flat Fork has shown no improvement in biology or chemistry since the last assessment. Flat Fork is expected to remain on the List of impaired waters after the 2019 assessment. With enough time for the recently installed BMPs to make a difference, Flat Fork may come off the list of impaired waters in the 2024 assessment if the benthic macroinvertebrate community recovers.

V. Effectiveness Monitoring.

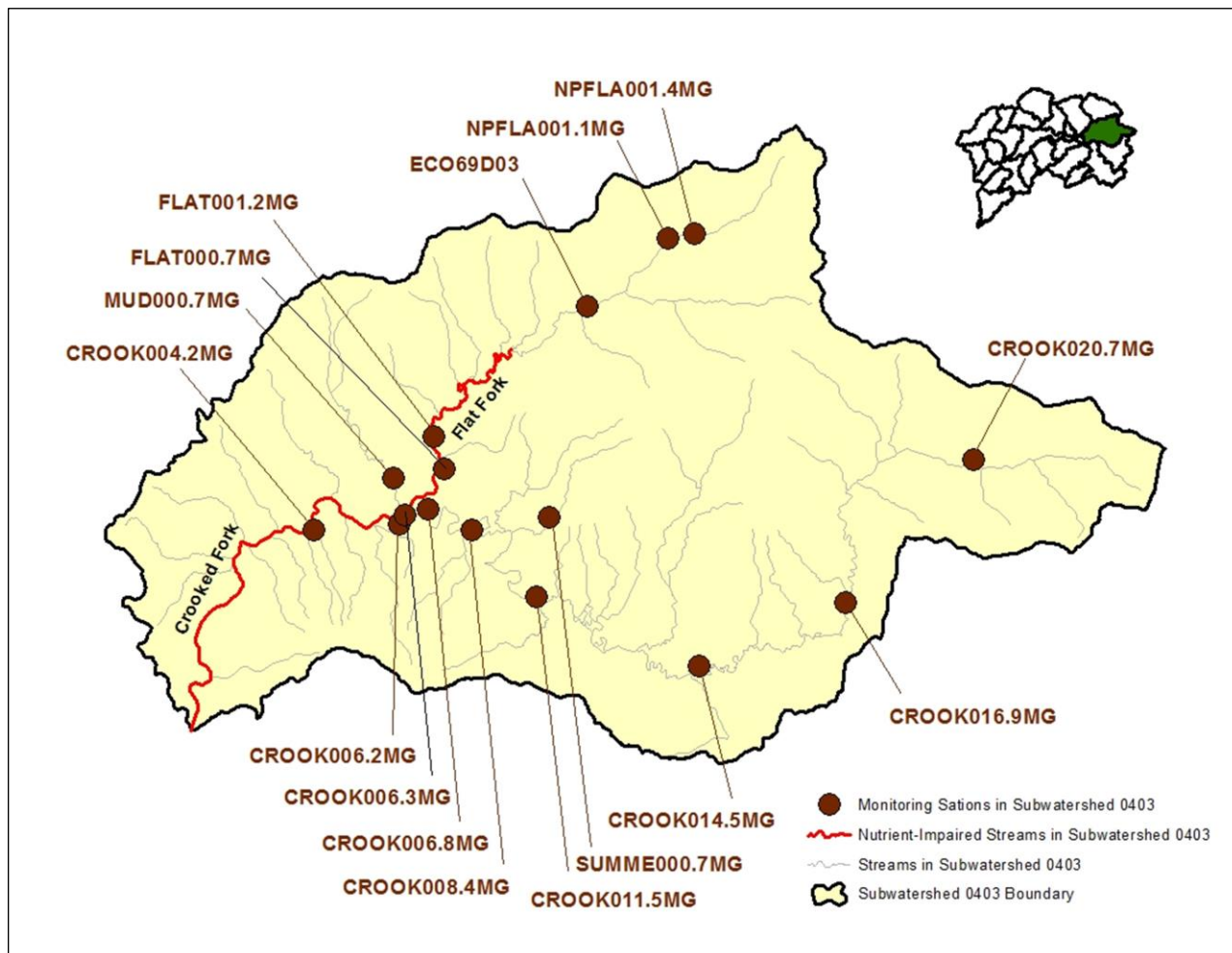


Figure 9. Illustration of Monitoring Sites in Crooked Fork Watershed.

Of the sixteen monitoring sites in the Crooked Fork Creek subwatershed, six are on the nutrient-impaired segments:

MONITORING SITE	LOCATION	COUNTY
CROOK004.2MG	Crooked Fork @ RM 4.2	Morgan
CROOK006.2MG	Crooked Fork @ RM 6.2	Morgan
CROOK006.3MG	Crooked Fork @ RM 6.3	Morgan
CROOK006.8MG	Crooked Fork @ RM 6.8	Morgan
FLAT000.7MG	Flat Fork @ RM 0.7	Morgan
FLAT001.2MG	Flat Fork @ RM 1.2	Morgan

Table 16. Monitoring Sites on Nutrient-Impaired Waters in HUC-12 Subwatershed 060102080403. RM, River Mile.

Ten sites are located on streams that are not impaired by nutrients:

MONITORING SITE	LOCATION	COUNTY
CROOK008.4MG	Crooked Fork @ RM 8.4	Morgan
CROOK011.5MG	Crooked Fork @ RM 11.5	Morgan
CROOK014.5MG	Crooked Fork @ RM 14.5	Morgan
CROOK016.9MG	Crooked Fork @ RM 16.9	Morgan
CROOK020.7MG	Crooked Fork @ RM 20.7	Morgan
NPFLA001.1MG	North Prong Flat Fork @ RM 1.1	Morgan
NPFLA0001.4MG	North Prong Flat Fork @ RM 1.4	Morgan
ECO69D03	Flat Fork @ RM 5.0	Morgan
MUD0007.MG	Mud Creek @ RM 0.7	Morgan
SUMME000.7MG	Summers Branch @ RM 0.7	Morgan

Table 17. Additional Monitoring Sites in HUC-12 Subwatershed 060102080403. RM, River Mile.

Only monitoring sites that are on nutrient-impaired waters will be discussed in remainder of this report.

Monitoring data from nutrient-impaired waters in Crooked Fork Creek HUC-12 Subwatershed.

Nitrogen

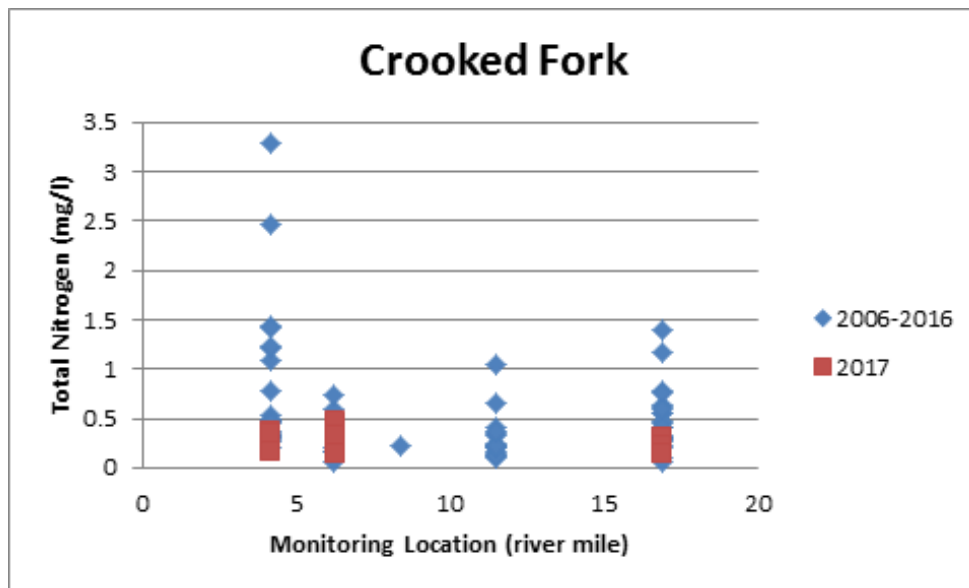


Figure 10. Total Nitrogen Data from Crooked Fork Monitoring Sites 2006-2017.

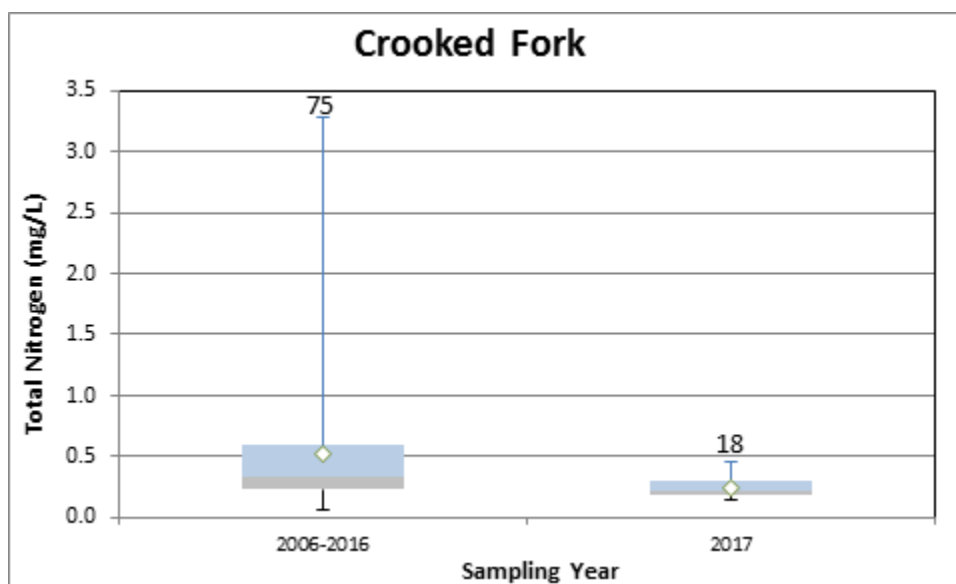


Figure 11. Comparison of Total Nitrogen at Crooked Fork Monitoring Sites Between 2006-2016 and 2017 Monitoring Seasons. Numbers indicate number of samples in the analysis (n).

Figures 10 and 11 illustrate that there were reductions in instream nitrogen concentrations in Crooked Fork monitoring stations from 2006-2016 and 2017 sampling seasons.

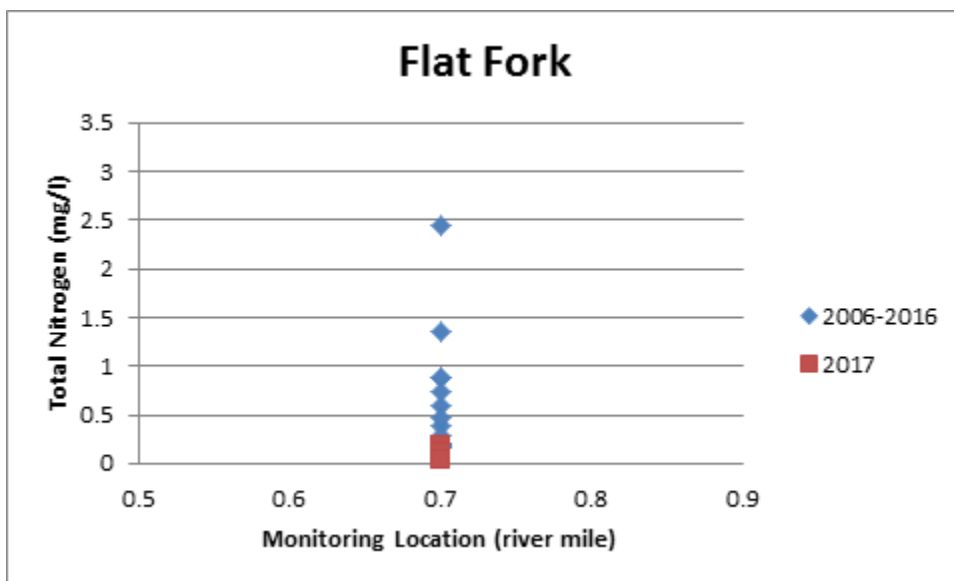


Figure 12. Total Nitrogen Data from Flat Fork Monitoring Site 2006-2017.

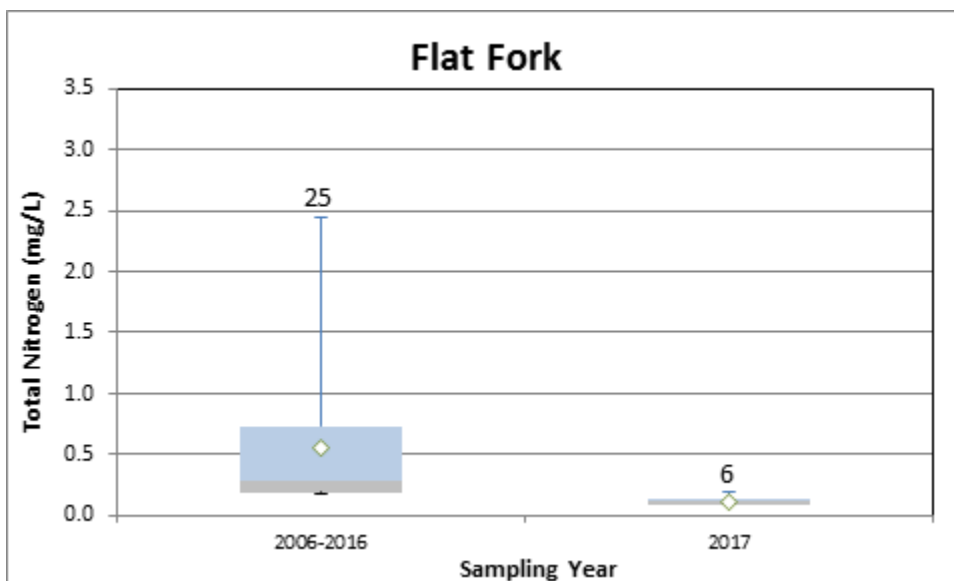


Figure 13. Comparison of Total Nitrogen at Flat Fork Monitoring Site Between 2006-2016 and 2017 Monitoring Seasons. Numbers indicate number of samples in the analysis (n).

Figures 12 and 13 illustrate that there were reductions in instream nitrogen concentrations in Flat Fork monitoring station from 2006-2016 and 2017 sampling seasons.

Phosphorus

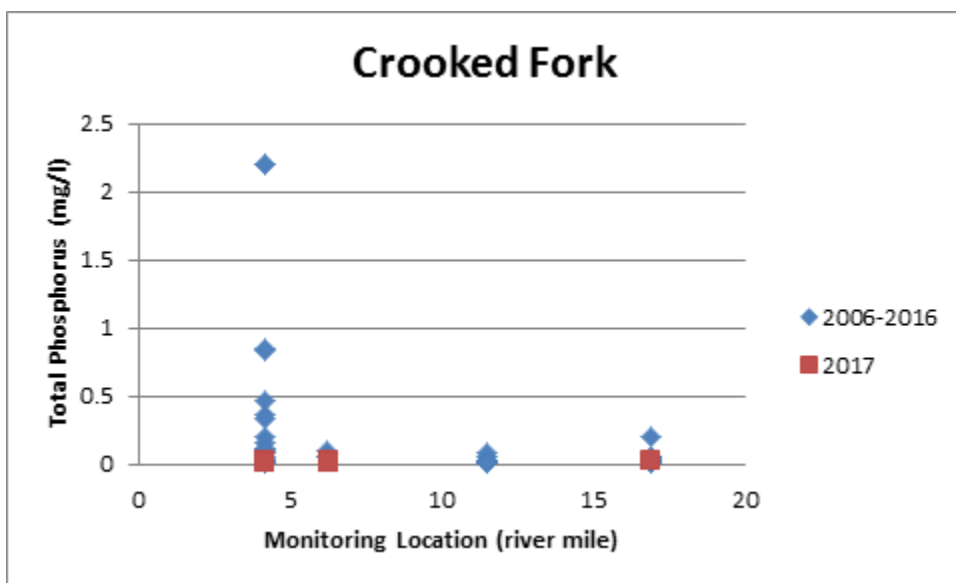


Figure 14. Total Phosphorous Data from Crooked Fork Monitoring Sites 2006-2017.

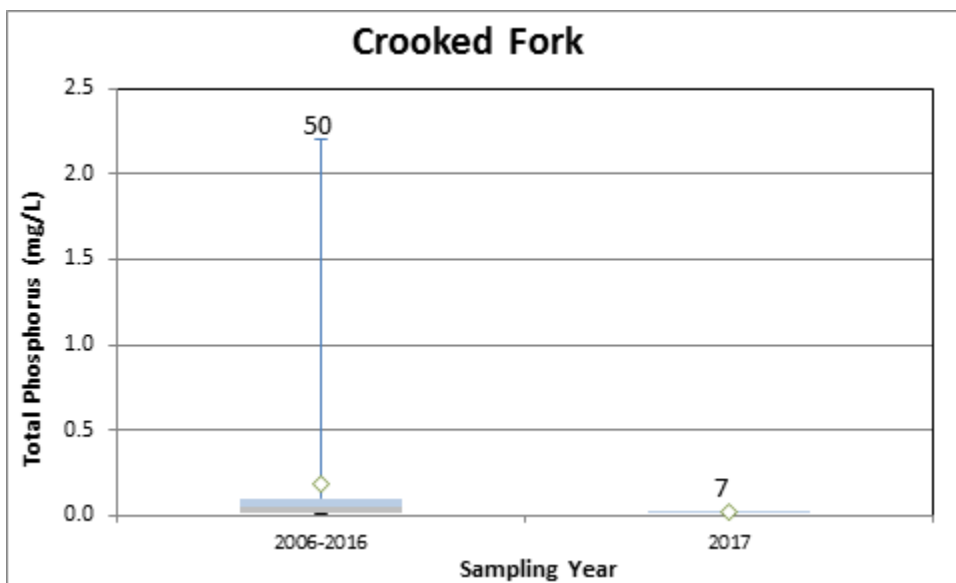


Figure 15. Comparison of Total Phosphorus at Crooked Fork Monitoring Sites Between 2006-2016 and 2017 Monitoring Seasons. Numbers indicate number of samples in the analysis (n).

Because phosphorus results were so low, semi-log plots were prepared for ease of viewing.

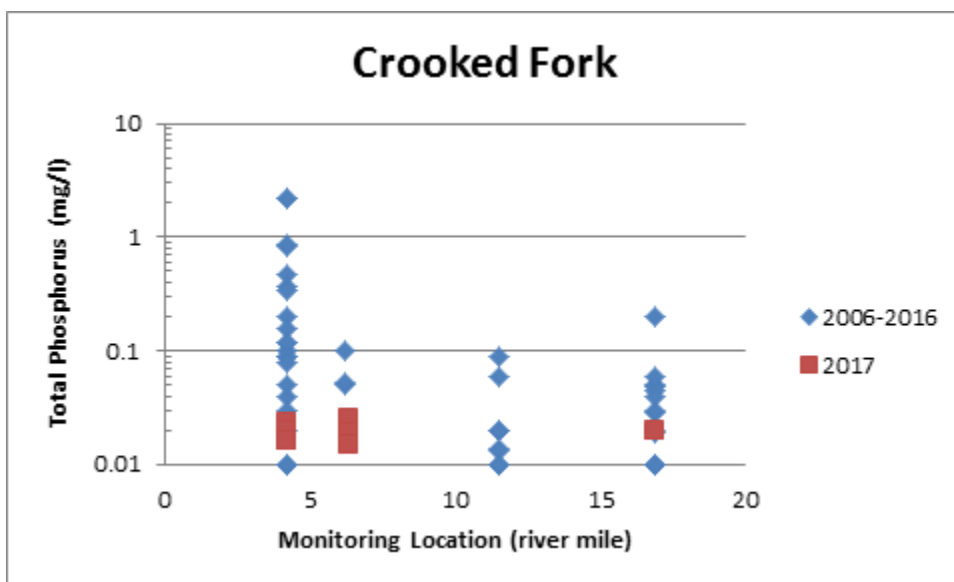


Figure 16. Total Phosphorous Data from Crooked Fork Monitoring Sites 2006-2017.

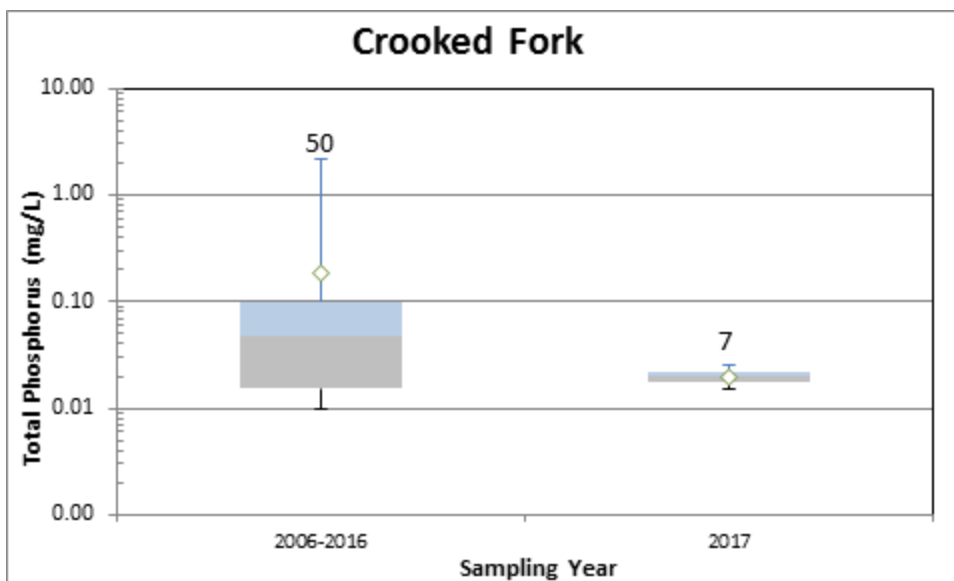


Figure 17. Comparison of Total Phosphorus at Crooked Fork Monitoring Sites Between 2006-2016 and 2017 Monitoring Seasons. Numbers indicate number of samples in the analysis (n).

Figures 14 and 15 (and figures 16 and 17) illustrate that there were reductions in instream phosphorus concentrations in Crooked Fork monitoring stations from 2006-2016 and 2017 sampling seasons.

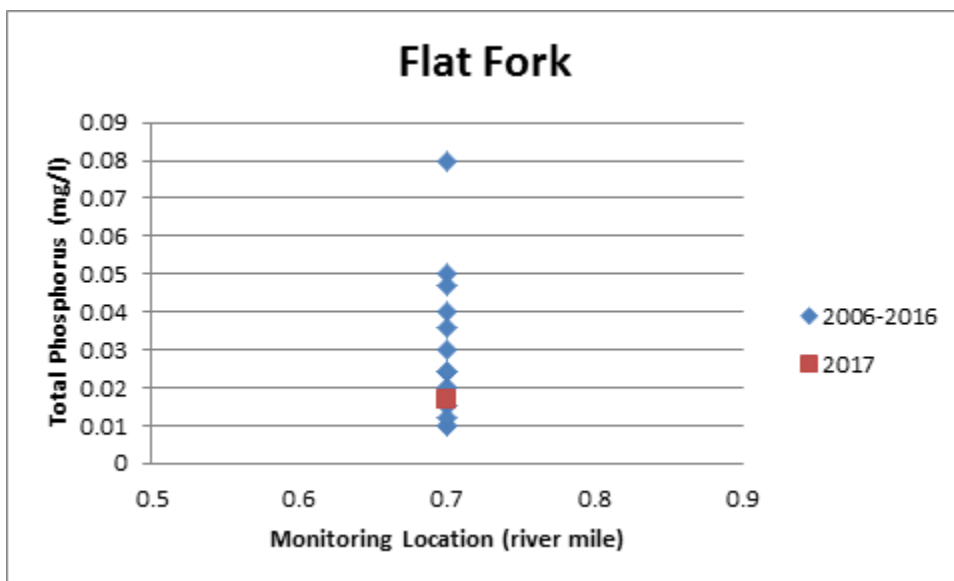


Figure 18. Total Phosphorus Data from Flat Fork Monitoring Sites 2006-2017.

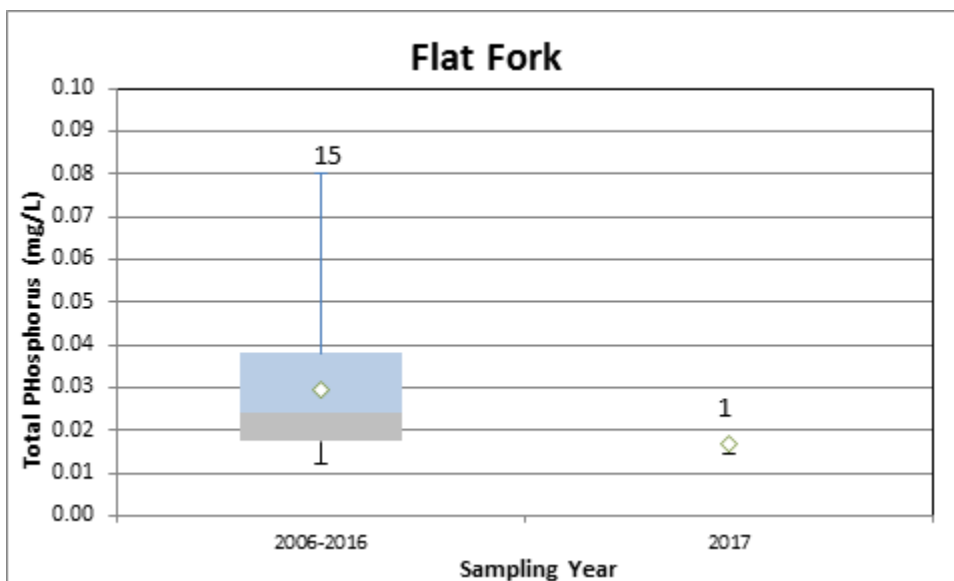


Figure 19. Comparison of Total Phosphorus at Flat Fork Monitoring Site Between 2006-2016 and 2017 Monitoring Seasons. Numbers indicate number of samples in the analysis (n).

Figures 18 and 19 illustrate that there were reductions in instream phosphorus concentrations in the Flat Fork monitoring station from 2006-2016 and 2017 sampling seasons.

Tennessee's nutrient water quality standards are narrative and have both a chemical (nutrients) and biological (e.g., benthic macroinvertebrates) component. Benthic macroinvertebrate data were collected from three sites on nutrient-impaired waters (two sites on Crooked Fork and one on Flat Fork). Monitoring on streams not impaired for nutrients (Mud Creek, North Prong Flat Creek, and Summer Branch) are not shown.

SITE	DATE	TMI	TOTAL TAXA	%EPT-CHEUM	% NUTRIENT TOLERANT	HABITAT SCORE
CROOK004.2MG	6/22/2006	32	26	53.9	22.3	182
CROOK004.2MG	9/20/2011	36	28	51.0	10.5	146

Table 18. Benthic Macroinvertebrate Data from Monitoring Site on Crooked Fork at RM 4.2. RM, River Mile; TMI, Tennessee Macroinvertebrate Index; EPT, Ephemeroptera, Plecoptera, Trichoptera; Cheum, Cheumatopsyche.

SITE	DATE	TMI	TOTAL TAXA	%EPT-CHEUM	% NUTRIENT TOLERANT	HABITAT SCORE
CROOK016.9MG	6/26/2002	26	37	20.7	19.2	99
CROOK016.9MG	6/22/2006	20	22	11.5	14.7	120
CROOK016.9MG	8/4/2011	20	33	9.6	39.2	111

Table 19. Benthic Macroinvertebrate Data from Monitoring Site on Crooked Fork at RM 16.9. RM, River Mile; TMI, Tennessee Macroinvertebrate Index; EPT, Ephemeroptera, Plecoptera, Trichoptera; Cheum, Cheumatopsyche.

Data Summary for Crooked Fork Monitoring Sites:

- TMI data from CROOK004.2MG site shows a passing score from 2006-2011 (passing score is 32)
- A decrease in %Nutrient tolerant data at CROOK004.2MG confirm this improvement (for this ecoregion and size, a score of less than 32% is close to reference conditions)
- All data at site CROOK016.9MG show a decrease in the benthic macroinvertebrate community from 2002-2011.
- More information about Tennessee's TMI score is in TDEC's Benthic macroinvertebrate SOP at: https://www.tn.gov/content/dam/tn/environment/water/documents/DWR-PAS-P-01-Quality_System_SOP_for_Macroinvertebrate_Stream_Surveys-081117.pdf.

SITE	DATE	TMI	TOTAL TAXA	%EPT-CHEUM	% NUTRIENT TOLERANT	HABITAT SCORE
FLAT000.7MG	6/6/2006	34	19	73.4	13.3	139
FLAT000.7MG	8/4/2011	22	29	19	32.2	124

Table 20. Benthic Macroinvertebrate Data from Monitoring Site on Flat Fork at RM 0.7. RM, River Mile; TMI, Tennessee Macroinvertebrate Index; EPT, Ephemeroptera, Plecoptera, Trichoptera; Cheum, Cheumatopsyche.

Data Summary for Flat Fork Monitoring Site:

- Data at site FLAT000.7MG show a decrease in the benthic macroinvertebrate community from 2006-2011
- More information about Tennessee's TMI score is in TDEC's Benthic macroinvertebrate SOP at: <https://www.tn.gov/content/dam/tn/environment/water/documents/DWR-PAS-P-01-Quality System SOP for Macroinvertebrate Stream Surveys-081117.pdf>

It's important to note that these data were collected as the BMPs were being implemented, or shortly after some were implemented, indicating that more time post-BMP implementation is needed before additional improvement is documented.

The next water quality assessment may result in splitting the Crooked Fork segment to recognize the downstream segment improvement in water quality (nutrients have decreased and biology has improved). It's also possible the 1) the entire segment will show improvement, or 2) the segment will show improvement but will remain on the list of impaired waters for one more cycle.

VI. Current and Future Activities.

The current 319 grant to the Morgan County Soil Conservation for work in Crooked Fork Subwatershed is still active and recruiting additional landowners to participate in installing BMPs designed to improve water quality. Request For Proposals for the next round of grants are due December 1, 2018.

USDA-NRCS continues to fund projects through the Environmental Quality Incentives Program (EQIP), and other qualifying Farm Bill Conservation Title programs.

VIII. Further Information.

For further information about TMDLs and 5-alt documents in Tennessee, visit the TDEC/DWR web site:

<https://www.tn.gov/environment/program-areas/wr-water-resources/watershed-stewardship/tennessee-s-total-maximum-daily-load--tmdl--program.html>

Technical questions regarding this 5-alt report should be directed to:

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Manager, Watershed Unit
david.duhl@tn.gov

LIST of INITIALS and ACRONYMS USED

303(d). Section 303(d) of the Clean Water Act that addresses impaired waters.

ARCF. Agricultural Resources Conservation Fund.

BMP. Best Management Practice.

Cheum. Cheumatopsyche insect Genus.

Crk. Creek.

CWA. Clean Water Act.

DMR. Discharge Monitoring Report.

DWR. Division of Water Resources.

EF. Enrichment Factor.

EPA. Environmental Protection Agency.

EPT. Ephemeroptera, Plecoptera, Trichoptera insect Orders.

EQIP. Environmental Quality Incentives Program.

ERWA. Emory River Watershed Association.

FY. Fiscal Year.

HUC. Hydrologic Unit Code.

HUC-10. Ten-Digit Hydrologic Unit Code.

HUC-12. Twelve-Digit Hydrologic Unit Code.

MGD. Million Gallons per Day.

NPDES. National Pollutant Discharge Elimination System.

USDA-NRCS. Natural Resources Conservation Service.

RC&D. Resource Conservation and Development.

RFP. Request for Proposals.

RM. River Mile.

SCD. Soil Conservation District.

SPARROW. Spatially Referenced Regression on Watershed attributes.

STP. Sewage Treatment Plant.

TDA. Tennessee Department of Agriculture.

TDEC. Tennessee Department of Environment and Conservation.

TMDL. Total Maximum Daily Load.

TMI. Tennessee Macroinvertebrate Index.

TVA. Tennessee Valley Authority.

UD. Utility District.

USDA. United States Department of Agriculture.

UT-Ext. University of Tennessee Extension.

WECO. Call letters for a radio station in Wartburg, Tennessee.

WWTP. Wastewater Treatment Plant.

REFERENCES CITED

A Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program” (December 2013)

https://www.epa.gov/sites/production/files/2015-07/documents/vision_303d_program_dec_2013.pdf

Tennessee Prioritization of TMDLs document under the New Vision

https://www.tn.gov/content/dam/tn/environment/water/tmdl-program/wr-ws_tmdl-priority-framework-101415.pdf

TDEC Watershed Approach

<https://www.tn.gov/environment/program-areas/wr-water-resources/watershed-stewardship/watershed-management-approach.html>

C. Jerry Nelson (editor). Conservation Outcomes from Pastureland and Hayland Practices: Assessment, Recommendations, and Knowledge Gaps. Chapter 5: Nutrient Management on Pastures and Haylands (Wood, C.W., Moore, P.A., Joern, Brad C., Jackson, R.D., and Cabrera, M.L.). 2012.

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